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Abstract

THE COLD NEUTRON SEPARATION FROM THE SPECTRA OF THE HORISONTAL BEAMS OF THE V.V.R.S. REACTOR

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Lately it was shown that the introduction in a reactor neutron beam of a system of surfaces allowing total multiple neutron reflexion may provide an efficient means for obtaining relatively intensive neutron beams, whose spectrum is shifted to the low energy domain relative to the neutron spectrum incident on the system.

The purpose of the present paper was to establish the efficiency of this method as a function of :

1. quality of the reflective surface,
2. the angular horisontal divergence defined by the reflectant surfaces,
3. the axis angle of the two elements defining the thermal neutron path.

The measurements have been performed at the VVRS reactor horisontal neutron beam placing in the neutron beam a system containing two collimators with variable aperture, with axes at a variable angle.

Surfaces with several reflectivities were used for defining the collimation system.

The obtained results lead to the following conclusions:

1. the transmitted neutron energy spectra at high

energies are sensibly influenced by the reflectivity of surfaces composing the collimation system,

2. the integral transmitted neutron intensity and the energy spectra shift in the low energy range can be usefully modified by varying the collimation system's horisontal angular divergence and the relative reflectivity of the slit walls.

The experimental data showed that the building of a reflectant collimator system of "Soller type" is possible; such a system is in course of assembling to the VVRS reactor beam.

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Abstract

RESEARCH REACTOR

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The nuclear research reactor of the Republic of China is planned and installed as part of the nation's efforts to promote its atomic energy programme. This programme has two principal aims: (1) the application of nuclear energy for peaceful purposes through the uses of radioisotopes and the training of scientists for the establishment of nuclear power stations; (2) the utilization of the research work in nuclear energy as a focus and stimulus to the national movement in upgrading science education and encouraging general research in science and technology.

The first nuclear reactor, a one-megawatt light-water, open-pool type, was installed at the Institute of Nuclear Science, National Tsing Hua University, at Hsin Chu, Taiwan, China.

The reactor went critical in April 1961. Its operation at Tsing Hua has given the University a twofold mission: to offer opportunities for study and research in nuclear science and to serve at the same time as a national laboratory and centre for the promotion of peaceful uses of atomic energy throughout the nation. Utilizing the reactor to accomplish these objectives, Tsing Hua has adopted the following steps: (1) offering a regular two-year M.S. degree programme in nuclear science and technology; (2) making the reactor available for research by other educational institutions and industries. Collaboration in research has also been worked out with other institutions; (3) production of short half-life radioisotopes for medical, industrial and agricultural uses. Already eight kinds of radioisotopes have been produced; (4) extending nuclear instrument maintenance and repairing service and health physics service to other institutions that are engaged in the atomic energy programme; (5) conducting training classes and symposiums on health physics,

application of radioisotopes, and nuclear instrument maintenance. Participants in these training classes include those from areas such as Hongkong, Vietnam. The above outline is an over-all plan of our atomic energy programme.

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Abstract

SEPARATION OF STABLE ISOTOPES BY THE GAS CENTRIFUGE METHOD INFLUENCE OF THE AXIAL PRESSURE ON THE SEPARATION OF ARGON ISOTOPES

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The installation for stable isotope separation by the gas centrifuge method, set up at this Instituto de Pesquisas Tecnologicas (Institute of Technological Research), São Paulo, Brazil, as well as the experiments performed in order to investigate the influence of the gas pressure at the axis of the centrifuge rotor on the separation of argon isotopes, are described. The installation consists of three thermally controlled countercurrent gas centrifuges, developed, as model ZG 3, by Groth and co-workers. These centrifuges are arranged in a two-stage cascade for the separation of argon isotopes. The description of this cascade, in which each centrifuge may also be operated as a single element, is given.

The influence of the axial pressure on the separation of argon isotopes was investigated with one of these centrifuges, by measuring the enrichment as a function of the throughput of the gas, under variation of the temperature difference between the rotor covers and for several axial pressures of the gas in the centrifuge rotor. The data from these experiments are used in order to calculate the enrichments at total reflux, as well as the separative power of the centrifuge as a function of the gas throughput. The results show that the enrichment and the separative power decrease as the axial pressure decreases and that greater optimal temperature differences between the rotor covers are necessary at the smaller axial pressures. For certain of these temperature differences, the presence of a maximum was observed at the separative power vs. throughput curves, which were provided by the experiments done with the smallest investigated axial pressure. The results are further discussed in view of the dependence of the separative power on the flow profile of the gas inside the centrifuge rotor.

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Abstract

NUCLEAR FUEL SUPPLYING. PROGRAM AND RESULTS IN BRAZIL

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Since its foundation, in 1956, and based upon its means and needs, the Brazilian National Nuclear Energy Commission has been fulfilling, without interruption, a program of equipping its field parties and laboratories and carrying out general and detailed mineral prospection.

Before the end of 1966 the National Nuclear Energy Commission expects to finish an appraisal of all readily available sources of nuclear ore in the national territory. In a parallel development a pilot plant was installed and has been working in problems related to the processing of Brazilian ores.

The Authors enumerate the following items upon which the mentioned program and accomplishments are based:

a. The preoccupation of keeping cost and prices within the limits set by the international representative standards;

b. Giving up, for the moment, any prospection work in territories too far away from the main centers of production and consumption;

c. The directive followed to prospect the selected areas rests on the following alternative options:

I. The study of facies of old and recent continental - detritic rocks;

II. The prospection of rocks of alkaline chimneys.

d. As a consequence, of the precedig options, the following rocks and formations are excluded for the moment from the prospecting operations:

I. The metamorphic formations which constitute the essential part of the Brazilian Shield;

II. The granitic formations, since the hydrothermal manifestations are scarce in Brazilian granites;

III. The pegmatitic formations from which economical extraction of nuclear minerals, even as by - products seems to be hopeless or at least, very unlikely:

IV. The occurence of Thorium bearing minerals as the detailed prospection of the already known sites could be carried out quickly if the needs required it.

The Authors show, in the following paragraphs, examples of strict application of a prospection sequence type which runs from the critical analysis of literature to the final detailed prospection, through the use of all techniques such as geochemistry, geophysics and airborne scintillometry. A general Table of methods reveals certain unusual variants of application. Next, information concerning each sector of study is condensed in a light Table where problems of peculiar nature, adopted solutions and attained results are recorded.

The Authors show, in conclusion, that everything was done to perform the work in the shortest time and at the lowest price. The ultimate goals of the National Nuclear Energy Commission of Brazil will be fully accomplished if an approximate inventory of its resources of nuclear ores the far reaching future and two or three Uranium deposits of reasonable size for meeting the needs of the Country in the next decade, is secured within - the estimated time.

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Abstract

DEVELOPMENTS IN THORIUM PRODUCTION TECHNOLOGY

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Recent development in the processing of thorium bearing ores and in the production of nuclear grade thorium oxide are reviewed with special reference to industrial and pilot plant experience in Brazil.

The alkaline process for breaking up monazite, as practiced in Brazil since 1948 on an industrial scale, presents from the point of view of thorium recovery, considerable advantage over other methods. In particular, yields are practically quantitative, separation factors of thorium from rare earths and phosphate are of the order of 100, and thorium is obtained in a form very suitable for solvent extraction purification. Working conditions, which allow obtaining satisfactory results under economic conditions, are presented.

Solvent extraction purification of thorium is discussed with special emphasis on: a) slurry extraction, b) thorium decontamination from rare earths and c) separation of thorium and uranium.

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Pilot experience with slurry extraction in mixer-settlers is reported. Emulsion formation in the extraction of unfiltered solutions of the crude thorium product from alkaline attack of monazite is prevented by the use of active carbon as de-emulsifying agent.

Satisfactory decontamination of thorium from the rare earths, which constitute the main impurity (10%) in the crude thorium product, presents some peculiar problems if the scrubbing operation is performed in pulsed extraction columns. Whereas increasing thorium concentrations in the tributylphosphate solvent improves the thorium-rare earths single-stage separation factors, it severely reduces the rate of transfer of the minor constituents into the aqueous phase, resulting in high H.E.T.S. values.

Highly efficient thorium-uranium separation is obtained by using an extractive - precipitation procedure, which consists in contacting the solution of thorium nitrate in the organic solvent with a 20 - 30 % sulfuric acid solution. Thorium is simultaneously extracted and precipitated as sulfate, which remains wholly in the aqueous phase. Thorium - uranium separation factors of up to 20.000 are obtained in a single-stage operation. Appreciable decontamination of thorium from many other elements is achieved at the same time. A further advantage of the extractive precipitation procedure is the possibility of an easy recovery of the nitric acid, which can be recycled into the original dissolution process of the crude thorium concentrate.

After the transformation of thorium sulfate into a basic carbonate, a high purity thorium oxide is obtained by calcination.

Alternatively, conditions have been established for the direct precipitation of thorium oxalate from solutions of thorium nitrate in the organic solvent.

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Abstract

DEVELOPMENTS IN FUEL FABRICATION FOR RESEARCH REACTORS IN BRASIL

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The authors describe the experimental development studies carried out for the fabrication of fuel elements for the Argonaut reactor of the Instituto de Engenharia Nuclear, Rio de Janeiro,Gb and for the Re-Suco, a sub-critical assembly loaded with 40,1 mm UO_2 pellets, of the Instituto de Energia Atômica.

In both developments, the selection of the fabrication procedure has been established to utilize equipment which could be built under short notice by local manufacturers.

Before the actual fabrication of the fuel plates for the Argonaut reactor was started, extensive experimental studies with cermets of 50 % U_3O_8 of natural isotope content and 50 % aluminum powder were conducted. Utilizing U_3O_8 powder of the same grain size of that of the 20 % enriched oxide, the essential variables of the fabrication process could be properly determined. After study of the cast cladding process, the procedure was evolved to roll bonding of picture frame sets comprising the cermet, which has been previously sintered under argon. Two complete mock-up fuel elements with natural uranium were built to check the reproducibility of the results before the production of the actual fuel plates was started.

The picture frame sets were designed to provide complete cladding, including the ends of the plates, to the finally deformed thin core. Each fuel element comprises 17 plates, 2,5 mm thick, 72,5 mm wide and 610 mm long, with face cladding of 0,35 mm thick. Each plate contains 19,3 g of U-235. Experimental work consisted mainly of: charge preparation; compacting under variable pressures in dies of different geometries; presintering of the compacts under argon; assembly of the picture frame components; hot-rolling of the assembled welded sets, and the final cold rolling operations to meet the dimensional and physical specifications of the fuel plates.

The Re-suco sub-critical assembly contains 313 fuel elements, 1100 aluminum alloy tubes of 44 mm outside diameter, 40,5 mm inside diameter, 1309 mm total lenght, each of them with 50 pellets of 40,1 mm diameter and weighing 152 g. The total load requires 15.650 pellets weighing 2.379 kg.

Nuclear grade ammonium diuranate, produced at the IEA, was the starting material for the pellet fabrication. The fabrication process was thoroughly investigated in view of minimizing the operating costs. Through acurate control of the calcining, reduction and conditioning steps, a charge of high compactability has been obtained, which allows the pellet production with the required density of $6,8 \pm 0,2$ g/cm^3 under compacting pressure of only 1,2 t/cm^2; these pellets are further sintered under argon at a fast rate in a eight-zone, electrically heated, continuous sintering furnace. The reproducibility of the dimensions and density of the sintered pellets has found to be excellent.

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Abstract

EXPERIMENTAL STUDIES ON THE FABRICATION OF THIN FUEL PLATES WITH U_3O_8-Al CERMETS

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The paper describes the experimental work done on the fabrication of aluminum alloy clad fuel plates, 0,7 mm thick, containing a core of U_3O_8 cermet, which are of interest for fuel assemblies of advanced research reactors. The production of such very thin, totally clad fuel plates, does present many fabrication difficulties, which were finally overcome through systematic study of the production variables.

The plates were to be between 75 and 110 mm wide, with 0,15 to 0,20 mm thick face cladding on the 0,30 to 0,40 mm plastically deformed core, which was to contain between 50 and 70 % U_3O_8 dispersed with aluminum.

The investigation comprised both the cast cladding and the roll bonding of picture frame alternatives. The main variables studied were: a) for cast cladding: cermet preparation after pressing and sintering under argon; influence of the casting variables for the most suitable aluminum alloys (1100 and

M-388); conditioning and heat treatment of the cored ingots; hot rolling and final cold rolling to the final dimensions ; b) for roll bonding of picture frame sets: cermet insertion into the frame; assembly of the picture frame components; argon arc welding of the assembled sets; furnace soaking; hot roll bonding and final cold rolling. The thin plates thus p produced were examined by auto-radiography, by metallographic methods and were also subjected to corrosion tests, in hot de-ionized water.

Studies were further conducted on the shaping of the wide thin strips into corrugated shapes to be assembled in fuel elements of simple design which allows high UO_2/Al ratios.

The obtained results have shown that both procedures can be adopted, the cast cladding alternative being the process suitable for the fabrication of extra wide plates.